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RESEARCH MEMORANDUM

for the

Bureau of Aeronautics, Navy Department

AN INVESTIGATION OF THE AERODYNAMIC CHARACTERISTICS OF AN 0.08-SCALE MODEL OF THE CHANCE VOUGHT XF7U-1 AIRPLANE IN THE LANGLEY HIGH-SPEED 7- BY 10-FOOT TUNNEL PART III - LONGITUDINAL-CONTROL CHARACTERISTICS

TED NO. NACA DE308

By

Richard E. Kuhn and Thomas J. King, Jr.

Langley Memorial Aeronautical Laboratory
Langley Field, Va.

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SUMMARY

Tests have been conducted in the Langley high-speed 7- by 10-foot tunnel over a Mach number range from 0.40 to 0.91 to determine the stability and control characteristics of an 0.08-scale model of the Chance Vought XF7U-1 airplane. The longitudinal-control characteristics of the complete model are presented in the present report with a limited analysis of the results.

INTRODUCTION

At the request of the Bureau of Aeronautics, Navy Department, an investigation of the stability and control characteristics of an 0.08-scale model of the Chance Vought XF7U-1 airplane was conducted in the Langley high-speed 7- by 10-foot tunnel.

This report presents the results of the longitudinal-control tests. The results include lift, drag, and pitching-moment data for the complete model with ailevator deflections varying from 4.4° to -14° over an angle-of-attack range at Mach numbers varying from 0.40 to 0.91.

The present report is published with the purpose of presenting the data available at present from high-speed tests of the 0.08-scale model of the XF7U-1 airplane. Accordingly, no detailed analysis of

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the data has been made. The basic longitudinal stability characteristics are presented in reference 1 and the basic lateral stability characteristics are presented in reference 2.

COEFFICIENTS AND SYMBOLS

The system of axes used for the presentation of the data, together with an indication of the positive forces, moments, and angles, is presented in figure 1. Pertinent symbols are defined as follows:

C_L lift coefficient $\left(\frac{\text{Lift}}{qS}\right)$

C_D drag coefficient $\left(\frac{\text{Drag}}{qS}\right)$

C_m pitching-moment coefficient $\left(\frac{\text{Pitching-moment}}{qSc'}\right)$ measured about the 17-percent mean geometric chord position

q dynamic pressure $\left(\frac{1}{2}\rho V^2\right)$

ρ air density, slugs per cubic foot

V free-stream velocity, feet per second

M free-stream Mach number (V/a)

a speed of sound, feet per second

S wing area, square feet $(3.174\ ft^2)$

c' mean geometric chord, feet $(1.046\ ft)$

c chord, parallel to plane of symmetry

c_1 chord, perpendicular to 0.25c line

α angle of attack, measured from X-axis to fuselage center line, degrees

R Reynolds number, $\frac{\rho V c'}{\mu}$

μ absolute viscosity, lb sec/ft^2

δ control-surface deflection with reference to wing chord line parallel to the plane of symmetry, (c), degrees

$C_{m_\delta} = \frac{\partial C_m}{\partial \delta}$

$C_{L_\delta} = \frac{\partial C_L}{\partial \delta}$

denote partial derivative of a coefficient with respect to δ (measured at $\delta = 0^\circ$)

Subscripts:

a_l left ailevator

a_r right ailevator

APPARATUS AND METHODS

Model

The 0.08-scale steel model of the XF7U-1 airplane used in this investigation was constructed by Chance Vought Aircraft Pertinent dimensions of the model are presented in figure 2. The control surfaces (ailevators) were constant chord, true contour flaps with sealed gaps.

Tests

The model was tested through the Mach number range at various angles of attack and ailevator deflections. The model was tested on a sting support as shown in figure 3. In order to obtain tares, the model was also tested on wing-tip stings (fig. 4) with and without the center sting. A more complete description of the testing technique employed is given in reference 1.

The variation of test Reynolds number with Mach number for average test conditions is presented in figure 5. The Reynolds number was computed using a turbulence factor of unity. The degree of turbulence of the tunnel is not known but is believed to be small because of the high contraction ratio of the tunnel. The size of the model used in the present investigation leads to an estimated choking Mach number of 0.93 based on one-dimensional-flow theory. Experience has indicated that with this value of the

choking Mach number, the tunnel constriction effects should not invalidate the test results at tunnel Mach numbers below 0.90. Application of the blocking correction increases this limit to over 0.91.

Corrections

The test results have been corrected for the tare forces and moments produced by the support system and for deflections of the system under load.

The jet-boundary corrections were computed from the following equations which were determined by the method of reference 3:

$$\alpha = \alpha_M + 0.331C_{L_M}$$

$$C_D = C_{D_M} + 0.0058C_{L_M}^2$$

where the subscript M indicates measured value. The jet-boundary correction to the pitching moment was considered negligible.

The drag has been corrected for the buoyancy produced by the small longitudinal static-pressure gradient in the tunnel and all coefficients and Mach numbers were corrected for blocking by the model and its wake.

RESULTS AND DISCUSSION

The effects of control deflection on the aerodynamic characteristics of the complete model are presented in figure 6. The deflection of the support system caused the angle of attack of the model to change with speed. It was necessary therefore to cross plot the original test results at constant Mach numbers to obtain the curves shown in figure 6. The pitching-moment coefficients are presented about a center of gravity located at 17 percent of the mean geometric chord.

The control surfaces on this airplane are referred to as ailevators by Chance Vought Aircraft and are used for both longitudinal and lateral control. For longitudinal control both ailevators are deflected in the same direction and

act as elevators. The effectiveness of these ailevators in producing changes in the pitching-moment coefficient is presented in figure 7. The effectiveness parameter C_{m_δ} was determined from cross plots of the data from figure 6 and is defined as the slope of the pitching-moment coefficient versus ailevator deflection curve at zero ailevator deflection. The pitching-moment coefficient was found to vary linearly with deflection through the deflection range at the lower Mach numbers. At large deflections the effectiveness was somewhat reduced at the higher Mach numbers.

The effect of control deflection on the lift coefficient is presented in figure 8. This effect C_{L_δ} was determined from cross plots of the data from figure 6 and is defined as the slope of the lift coefficient versus ailevator deflection curve at zero ailevator deflection. The lift coefficient was found to vary linearly with deflection through the deflection range at the lower Mach numbers. At large deflections the effectiveness was somewhat reduced at the higher Mach numbers.

Figure 9 presents the variation with Mach number of the control position required for trim in level flight at sea level and at an altitude of 40,000 feet for wing loadings of 24 and 34 pounds per square foot. It should be noted that the variation of control position with speed becomes unstable above a Mach number of 0.90 at sea level and above 0.85 at an altitude of 40,000 feet. This behavior is largely a result of the rapid changes in the untrimmed-pitching-moment coefficient which occurs at the higher Mach numbers (fig. 10). For flight conditions at 40,000 feet the change in the untrimmed pitching moment occurs at the same Mach number (0.85) at which the variation of control position with speed becomes unstable (fig. 9). For sea-level flight, however, the unstable variation of control position with speed occurs at a slightly higher Mach number than that at which the rapid change in untrimmed pitching moment occurs (0.86). This effect occurs because the control effectiveness C_{m_δ} initially

decreases more rapidly with Mach number than the untrimmed-pitching-moment coefficient.

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REFERENCES

1. Kemp, William B., Jr., Kuhn, Richard E., and Goodson, Kenneth W.: An Investigation of the Aerodynamic Characteristics of an 0.08-Scale Model of the Chance Vought XF7U-1 Airplane in the Langley High-Speed 7- By 10-Foot Tunnel. Part I - Basic Longitudinal Stability Characteristics - TED No. NACA DE308. NACA RM No. L7G08, Bur. Aero., 1947.

2. Kemp, William B., Jr., Goodson, Kenneth W., and Kuhn, Richard E.: An Investigation of the Aerodynamic Characteristics of an 0.08-Scale Model of the Chance Vought XF7U-1 Airplane in the Langley High-Speed 7- By 10-Foot Tunnel. Part II - Basic Lateral Stability Characteristics - TED No. NACA DE308. NACA RM No. L7G10, Bur. Aero., 1947.

3. Gillis, Clarence L., Polhamus, Edward C., and Gray, Joseph L., Jr.: Charts for Determining Jet-Boundary Corrections for Complete Models in 7- By 10-Foot Closed Rectangular Wind Tunnel. NACA ARR No. L5G31, 1945.

FIGURE LEGENDS

Figure 1.- System of axes and control-surface deflections. Positive values of forces, moments, and angles are indicated by arrows.

Figure 2.- General arrangement of 0.08-scale model of Chance Vought XF7U-1 airplane.

Figure 3.- Photograph of the 0.08-scale model of the XF7U-1 airplane mounted on the center sting at a positive angle of attack.

Figure 4.- Photograph of the 0.08-scale model of the XF7U-1 airplane with vertical tails removed mounted on the wing supports with center sting in plane.

Figure 5.- Variation of test Reynolds number with Mach number for 0.08-scale XF7U-1 in the High Speed 7- by 10-foot tunnel.

Figure 6.- Effect of ailavator deflection on the aerodynamic characteristics in pitch of the 0.08-scale model of the Xf7U-1 airplane.

(a) M = 0.400

Figure 6.- Continued

(a) M = 0.400 Concluded

Figure 6.- Continued

(b) M = 0.600

Figure 6.- Continued

(b) M = 0.600 Concluded

Figure 6.- Continued

(c) M = 0.700

Figure 6.- Continued

(c) M = 0.700 Concluded

Figure 6.- Continued

(d) M = 0.800

FIGURE LEGENDS - Continued

Figure 6.- Continued

(d) M = 0.800 Concluded

Figure 6.- Continued

(e) M = 0.850

Figure 6.- Continued

(e) M = 0.850 Concluded

Figure 6.- Continued

(f) M = 0.875

Figure 6.- Continued

(f) M = 0.875 Concluded

Figure 6.- Continued

(g) M = 0.900

Figure 6.- Continued

(g) M = 0.900 Concluded

Figure 6.- Continued

(h) M = 0.910

Figure 6.- Concluded

(h) M = 0.910 Concluded

Figure 7.- Variation of the control-effectiveness parameter (C_{m_δ}) with Mach number for several angles of attack.

Figure 8.- Variation of C_{L_δ} with Mach number for several angles of attack

Figure 9.- Variation with Mach number of the control position required for trim in level flight at various altitudes and wing loadings.

Figure 10.- Variation with Mach number of the out-of-trim pitching moment of the model with zero control deflection for level flight at various altitudes and wing loadings.

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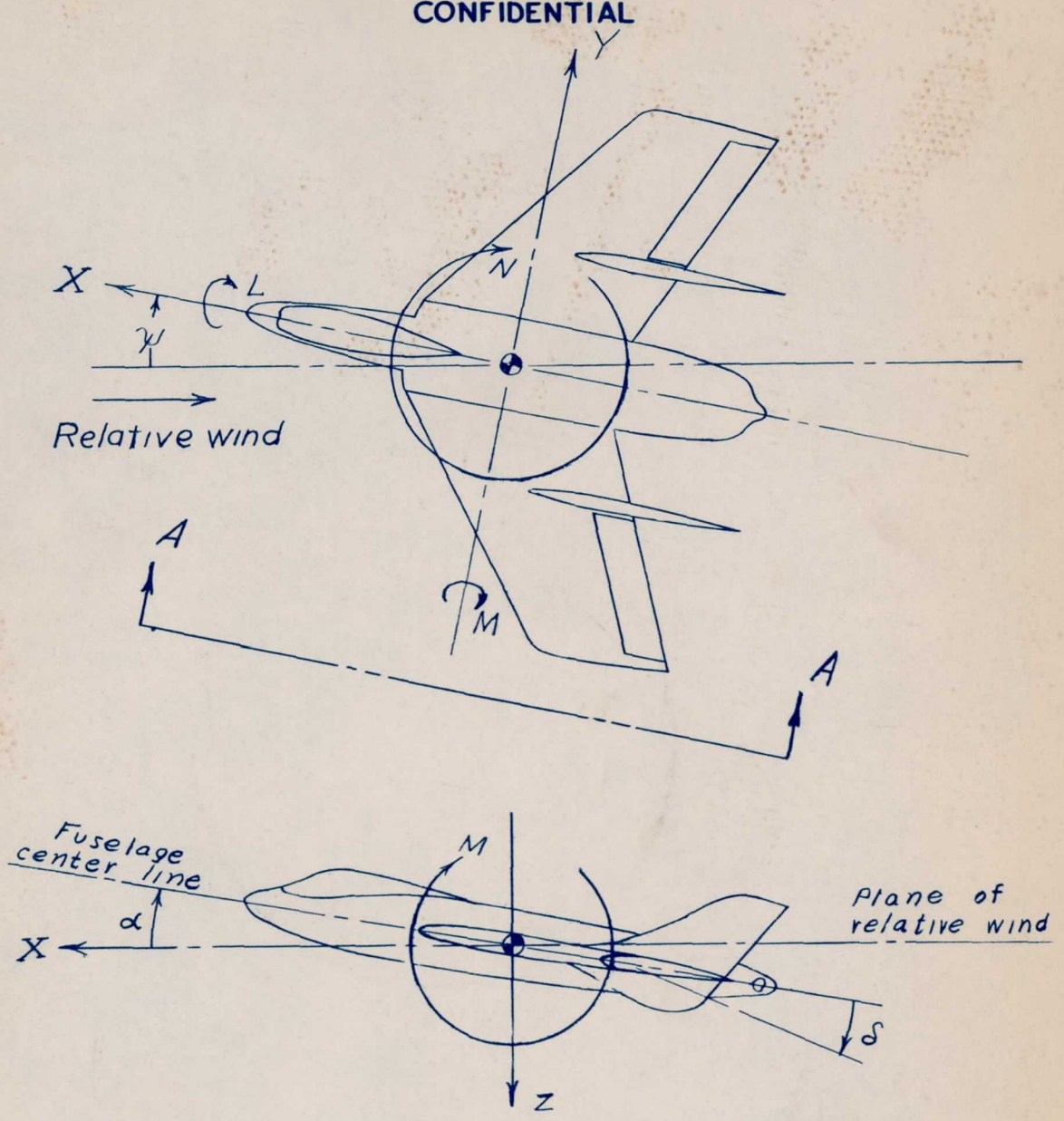

Figure 1 .- System of axes and control-surface deflections. Positive values of forces, moments, and angles are indicated by arrows.

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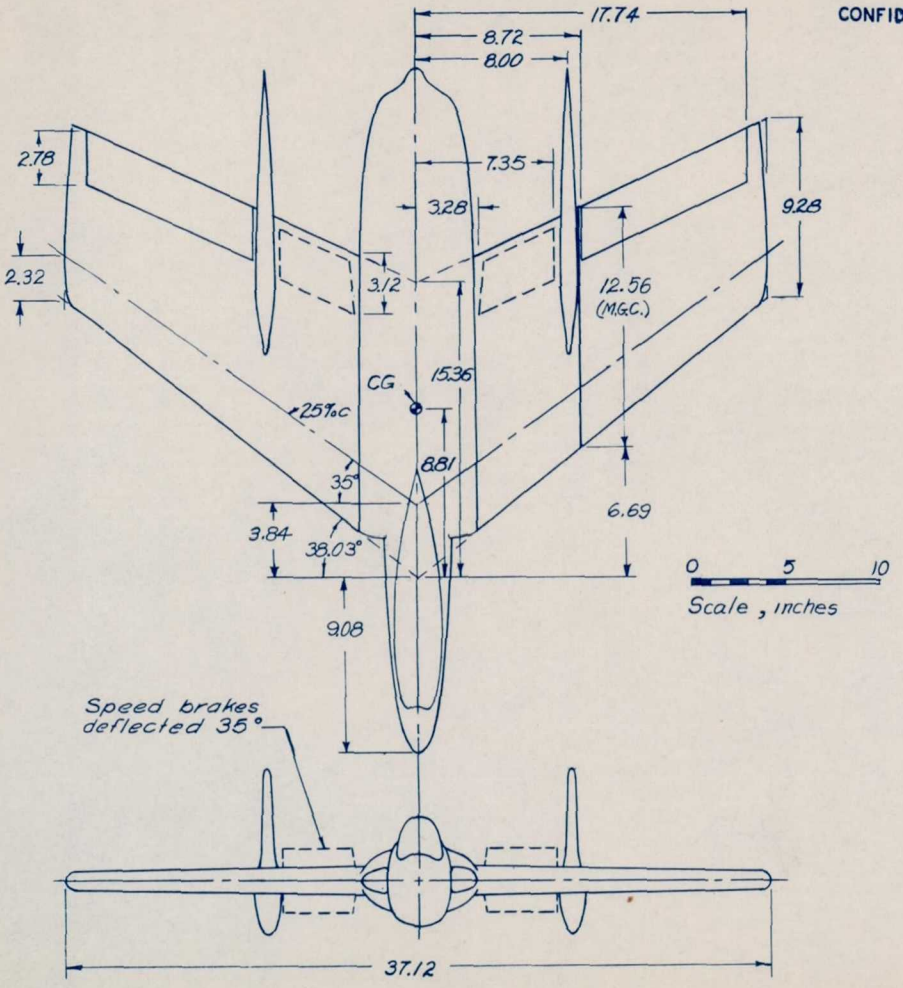

TABULATED DATA

Wing	
Area	3.174 sq. ft.
Aspect ratio	3.014
Mean geometric chord	1.046 ft.
Incidence	0°
Dihedral	0°
Airfoil (perpendicular to 0.25c)	Symmetrical
Max. thickness	0.12c
Location of max. thickness	0.40c
Vertical tail	
Area (two)	0.82 sq. ft.
Aspect ratio	1.75
CG location	0.17 M.G.C.

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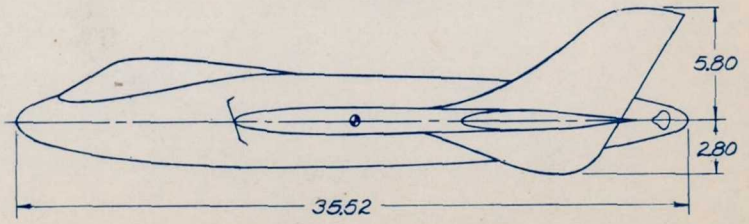

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Figure 2.- General arrangement of 0.08-scale model of Chance Vought XF7U-1 airplane.

Fig. 2

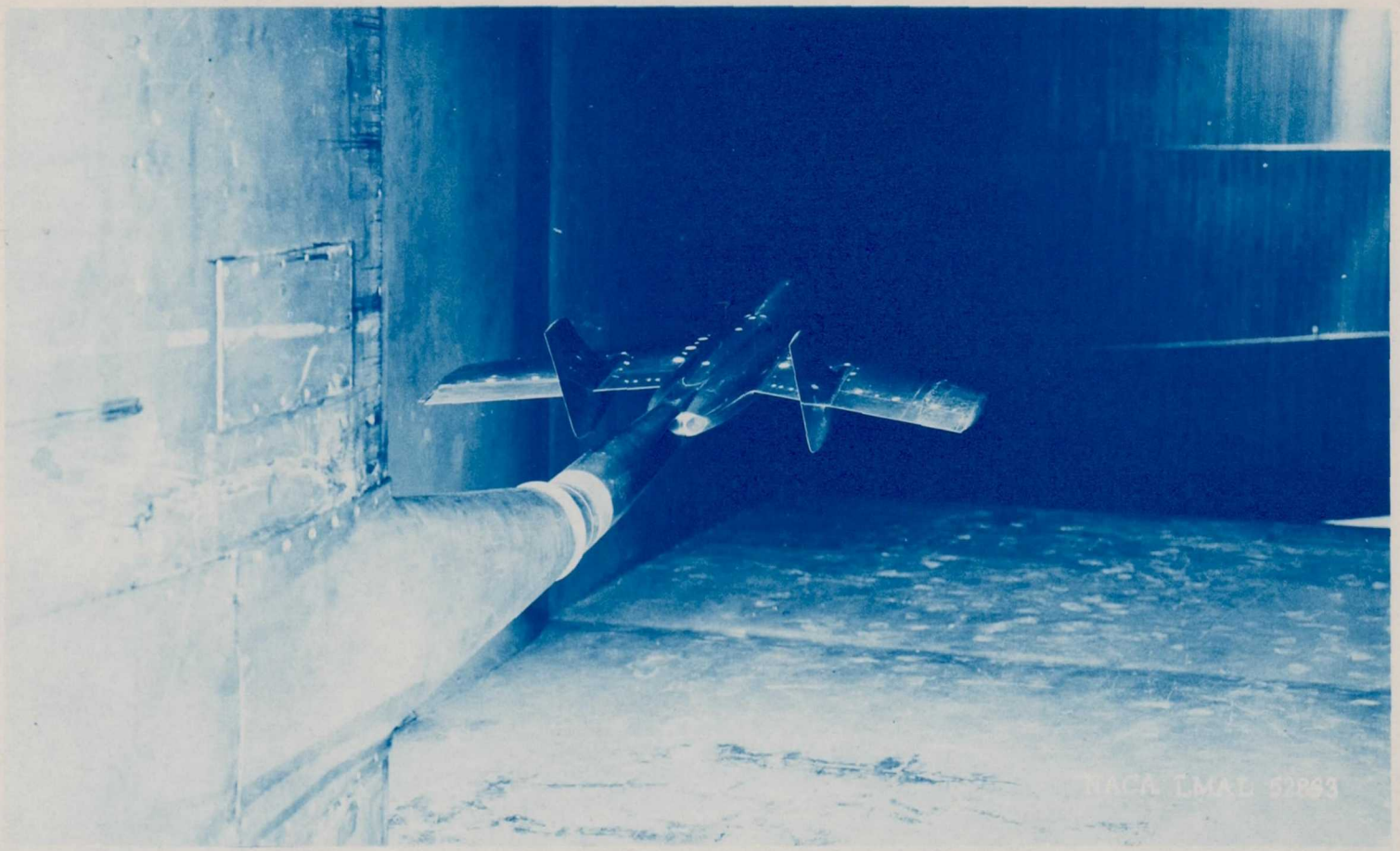

Figure 3.- Photograph of the 0.08-scale model of the XF7U-1 airplane mounted on the center sting at a positive angle of attack.

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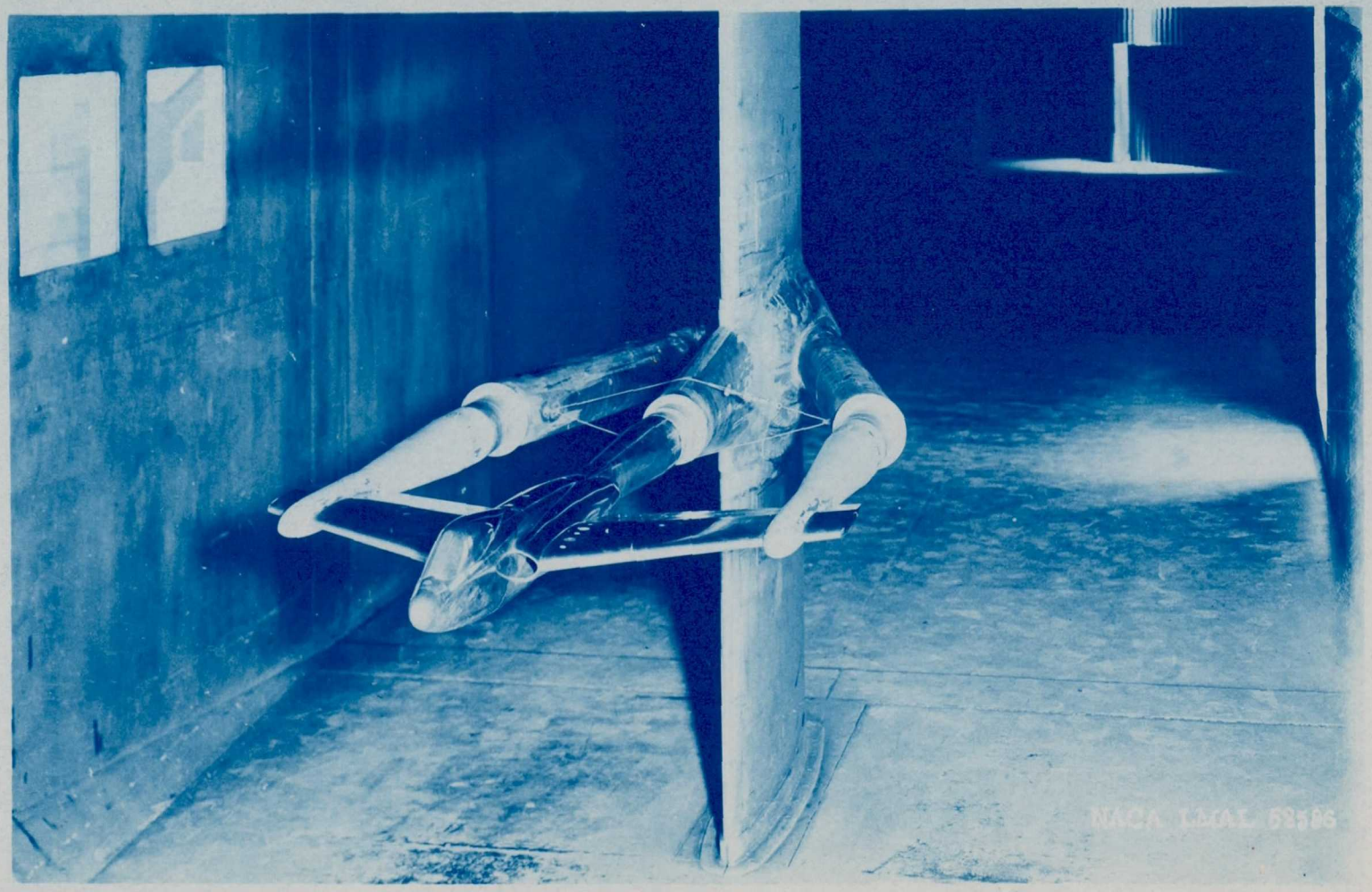

Figure 4.- Photograph of the 0.08-scale model of the XF7U-1 airplane with vertical tails removed mounted on the wing supports with center sting in place.

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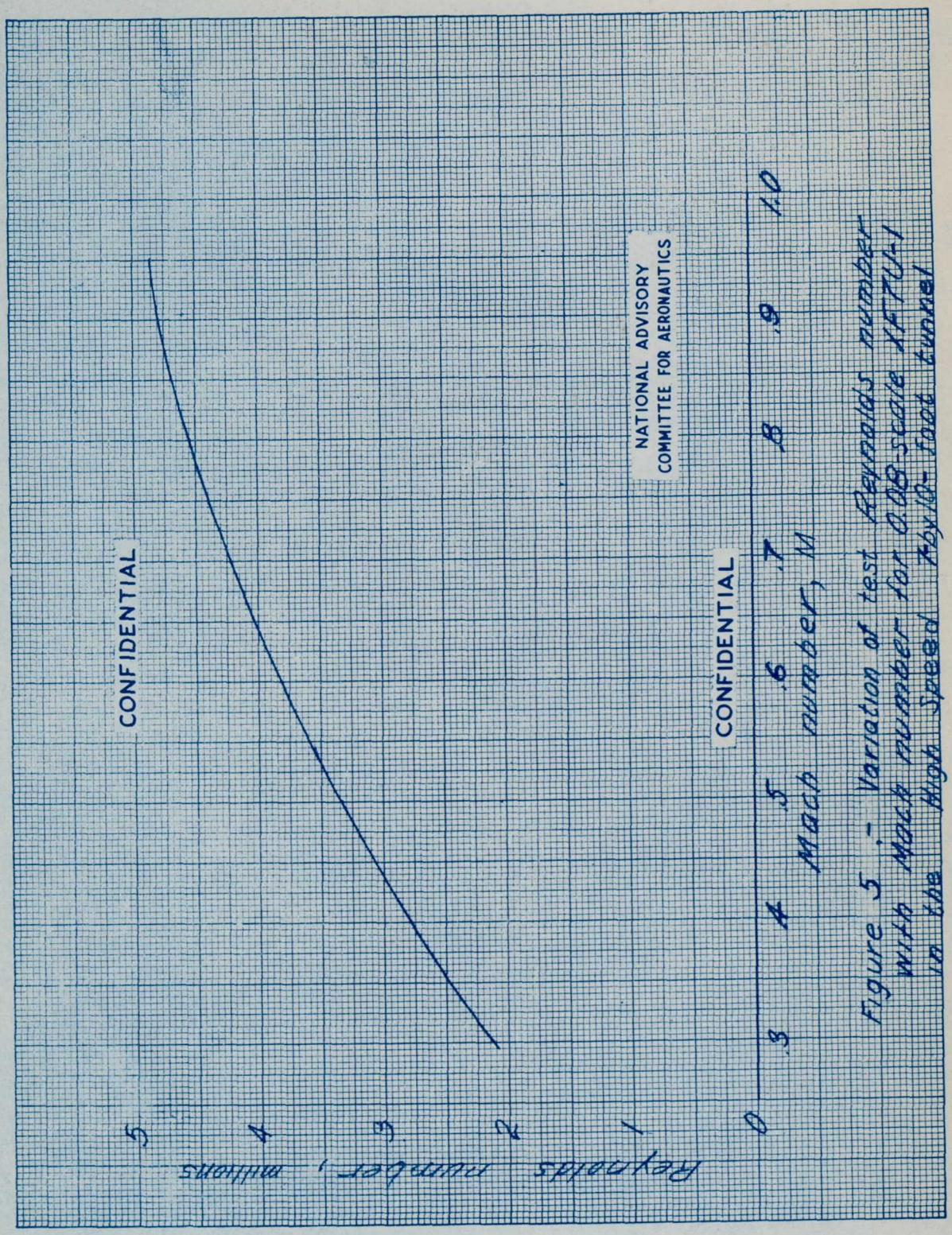

Figure 5 - Variation of test Reynolds number with Mach number for 0.09-scale LTV-1 in the high-speed flow 40- by 80-foot tunnel.

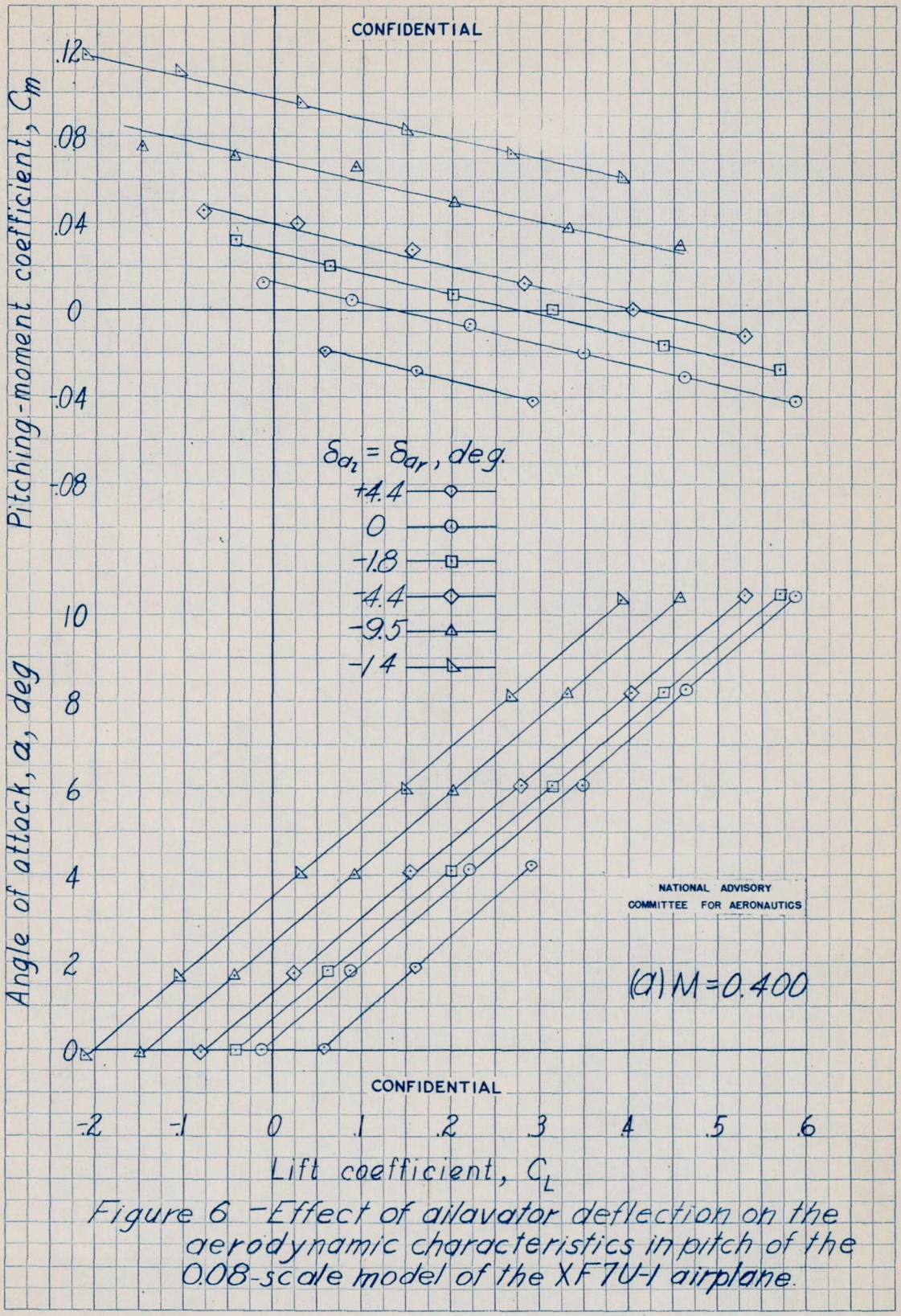

Figure 6 - Effect of dilavator deflection on the aerodynamic characteristics in pitch of the 0.08-scale model of the XF7U-1 airplane.

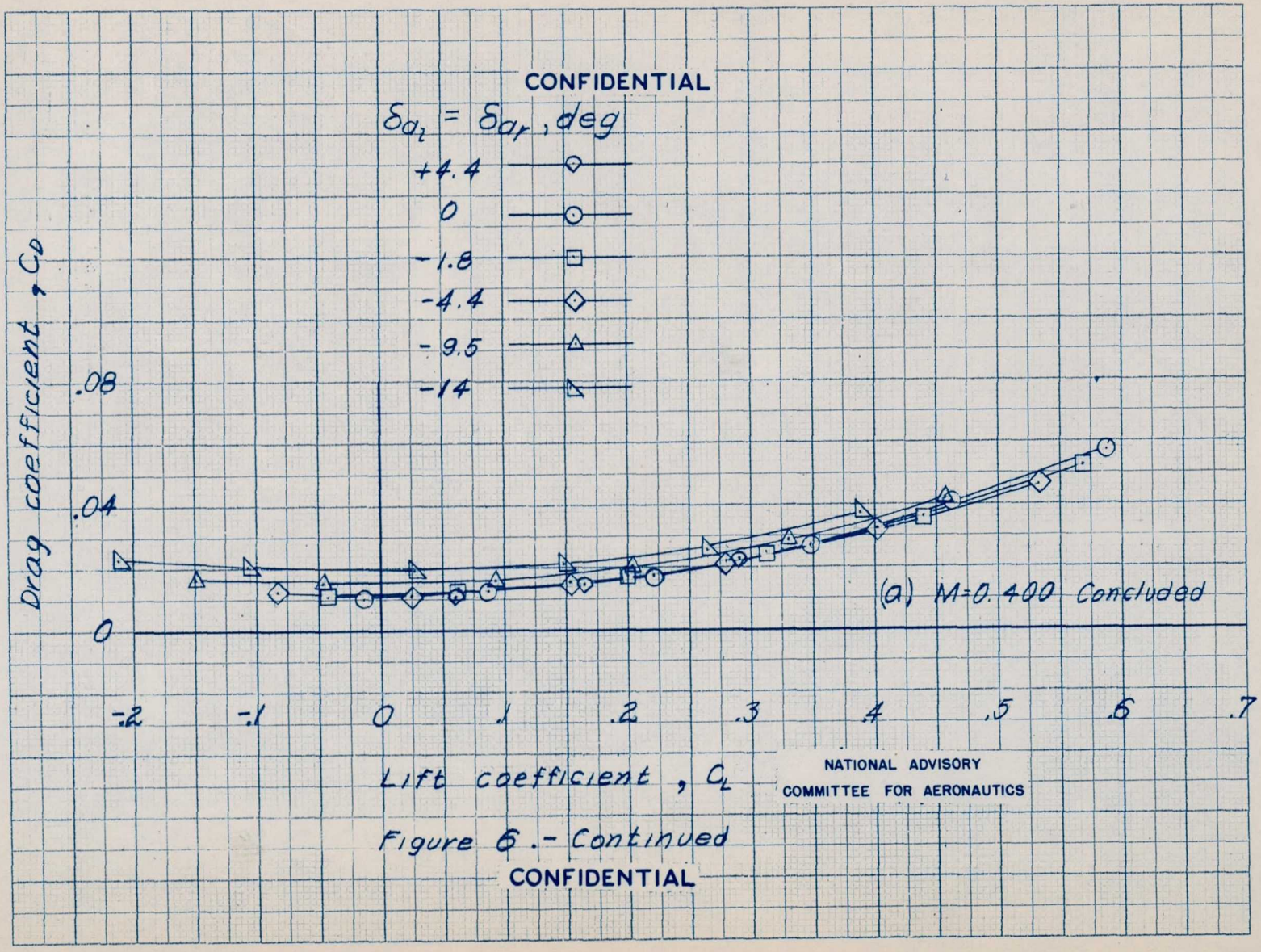

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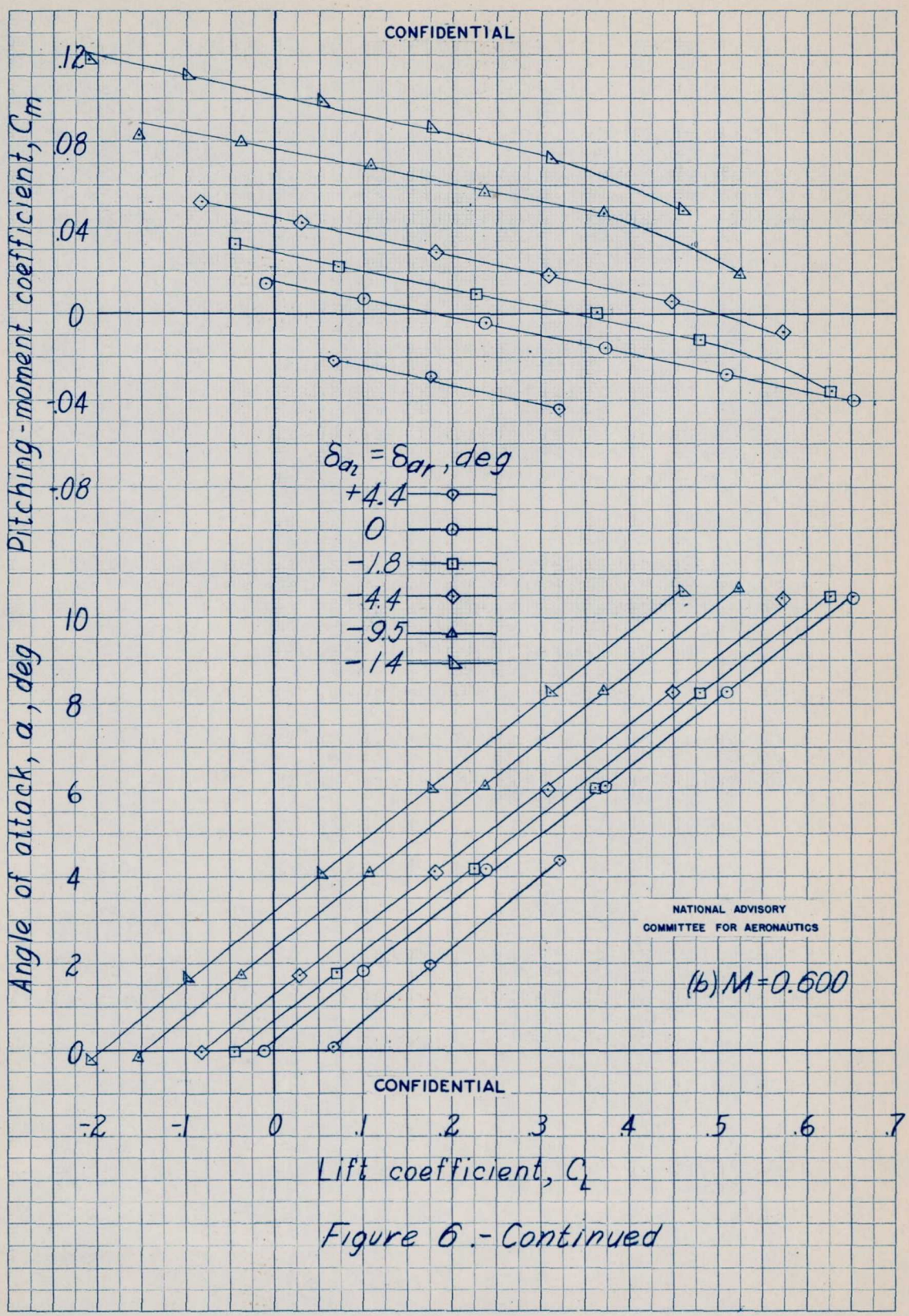
Fig. 6a conc.



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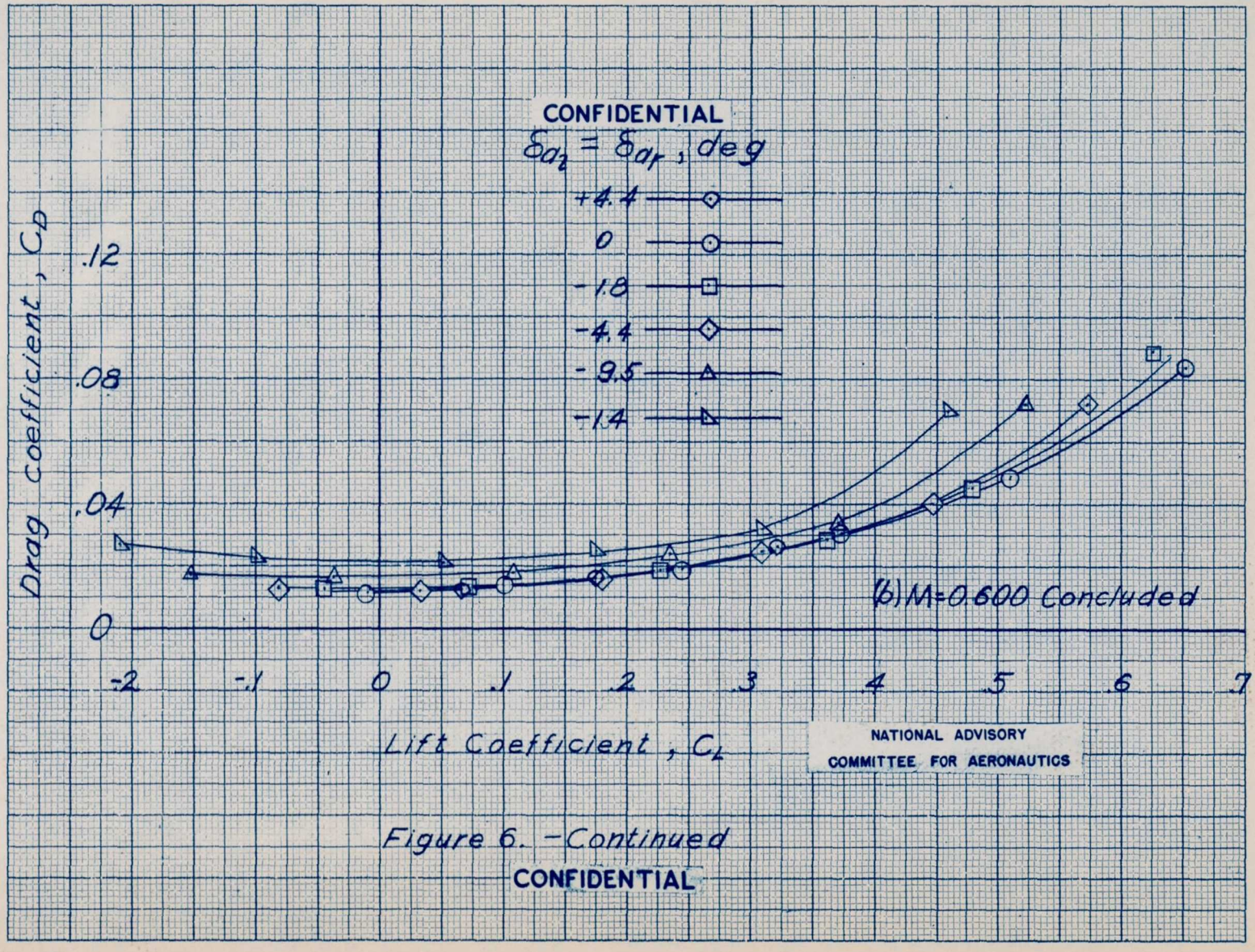

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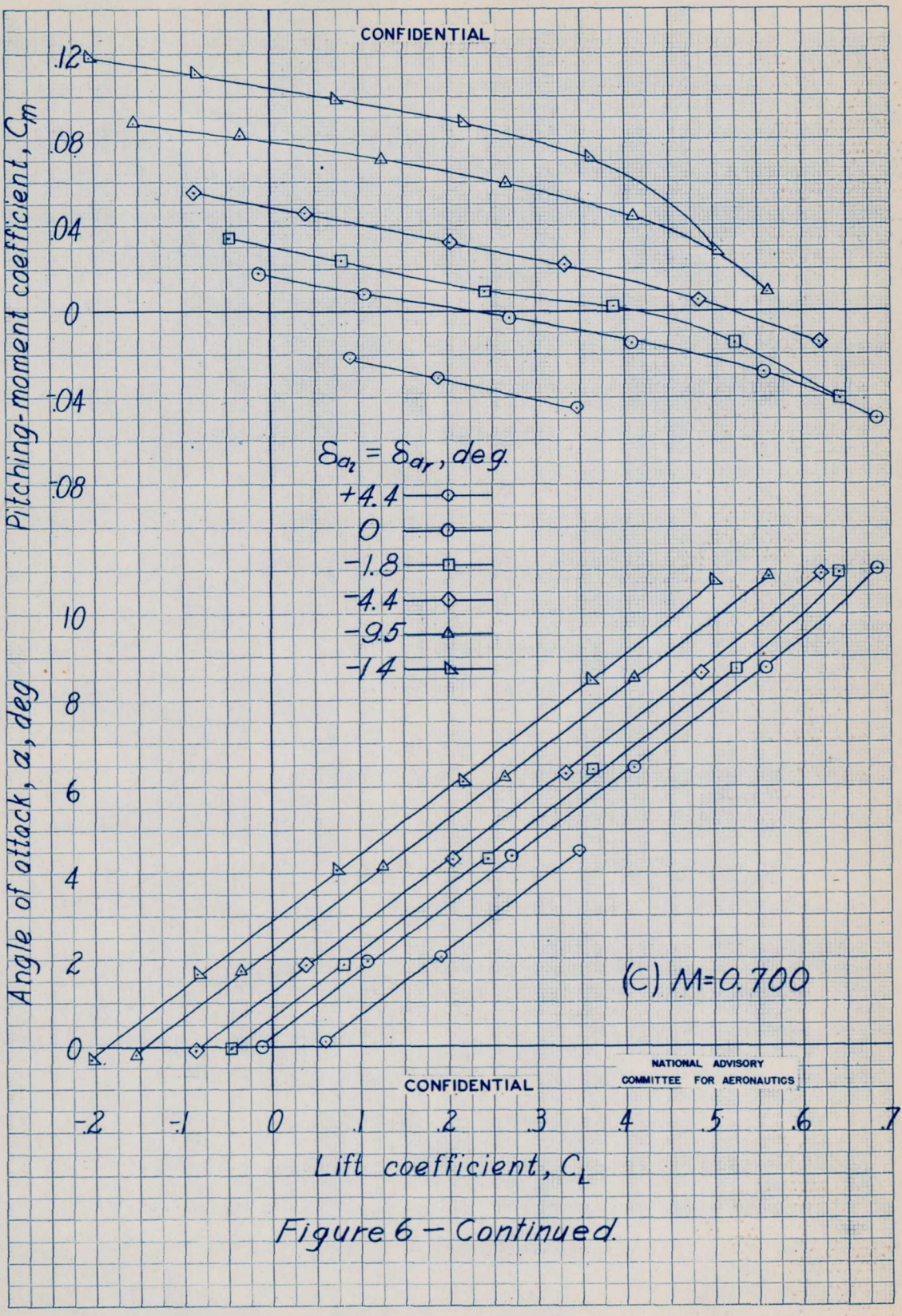

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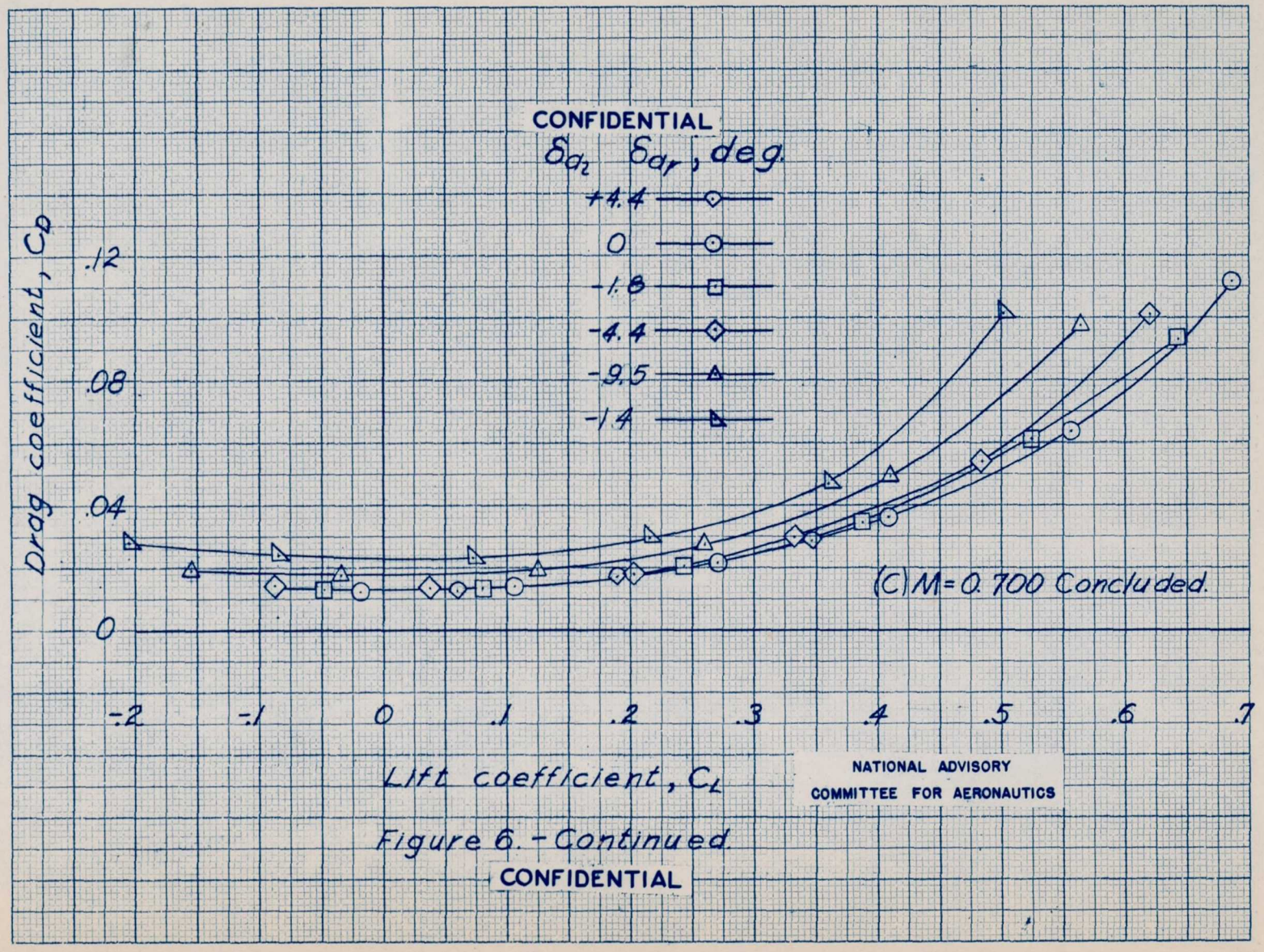

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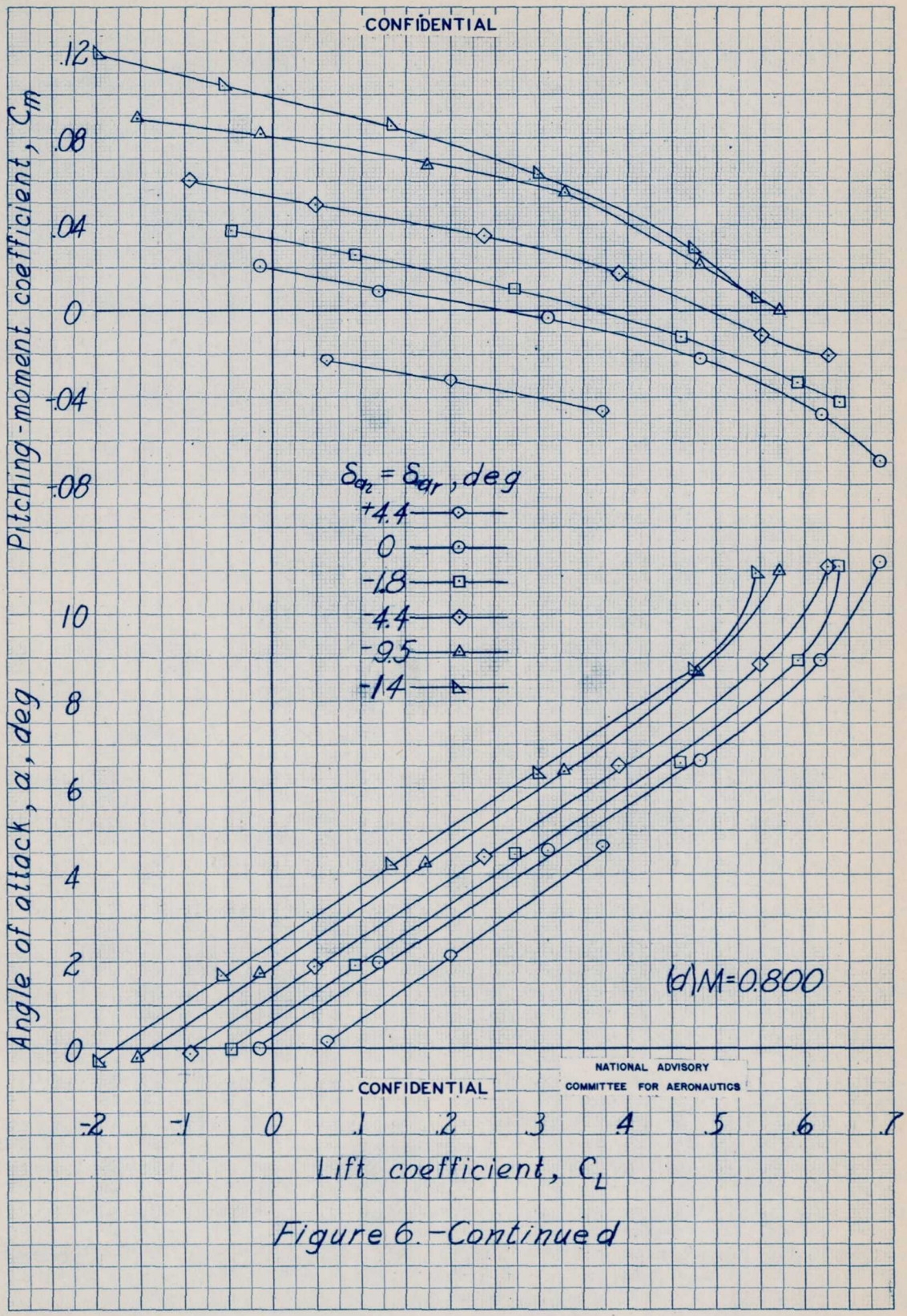

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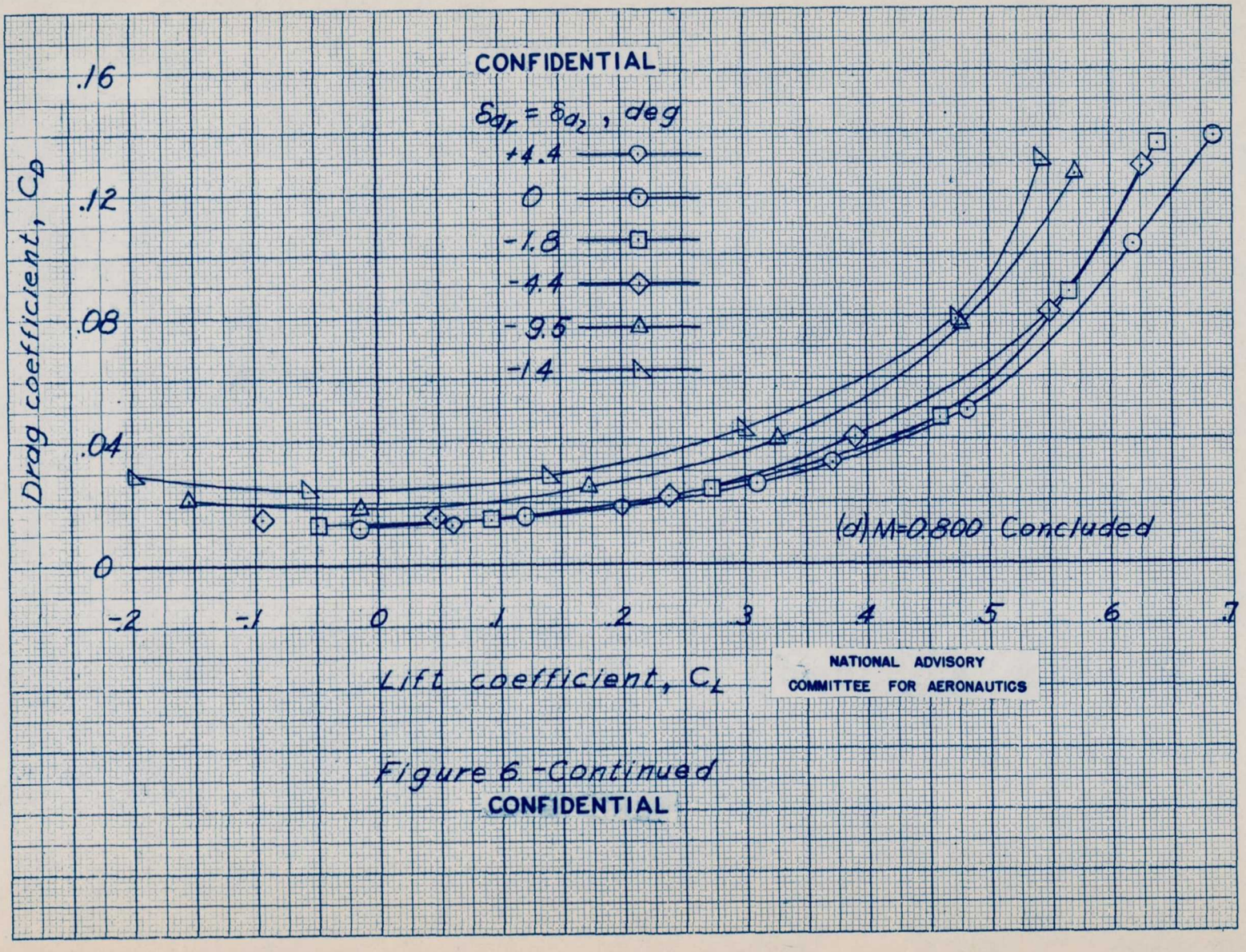

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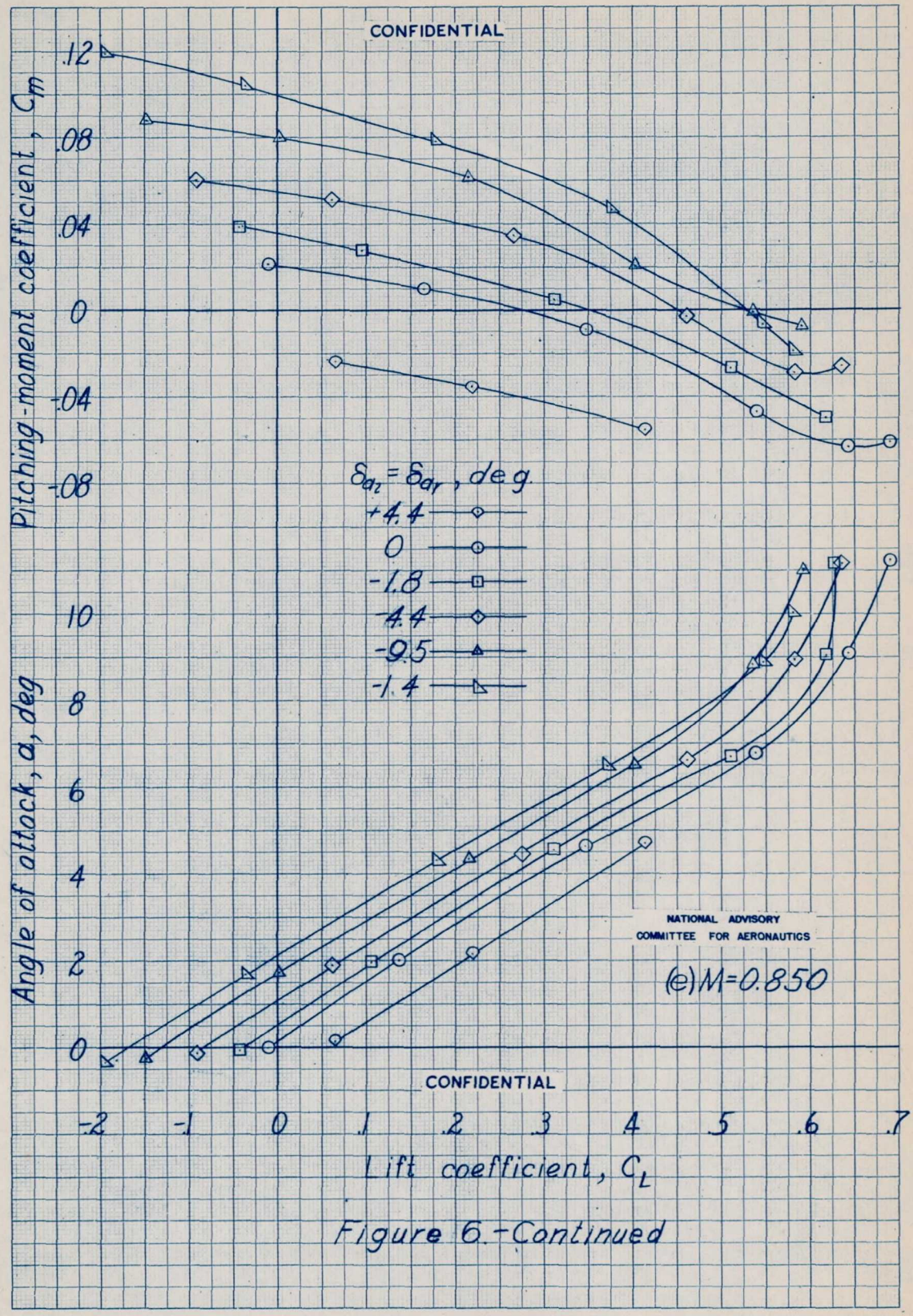
Fig. 6d conc.



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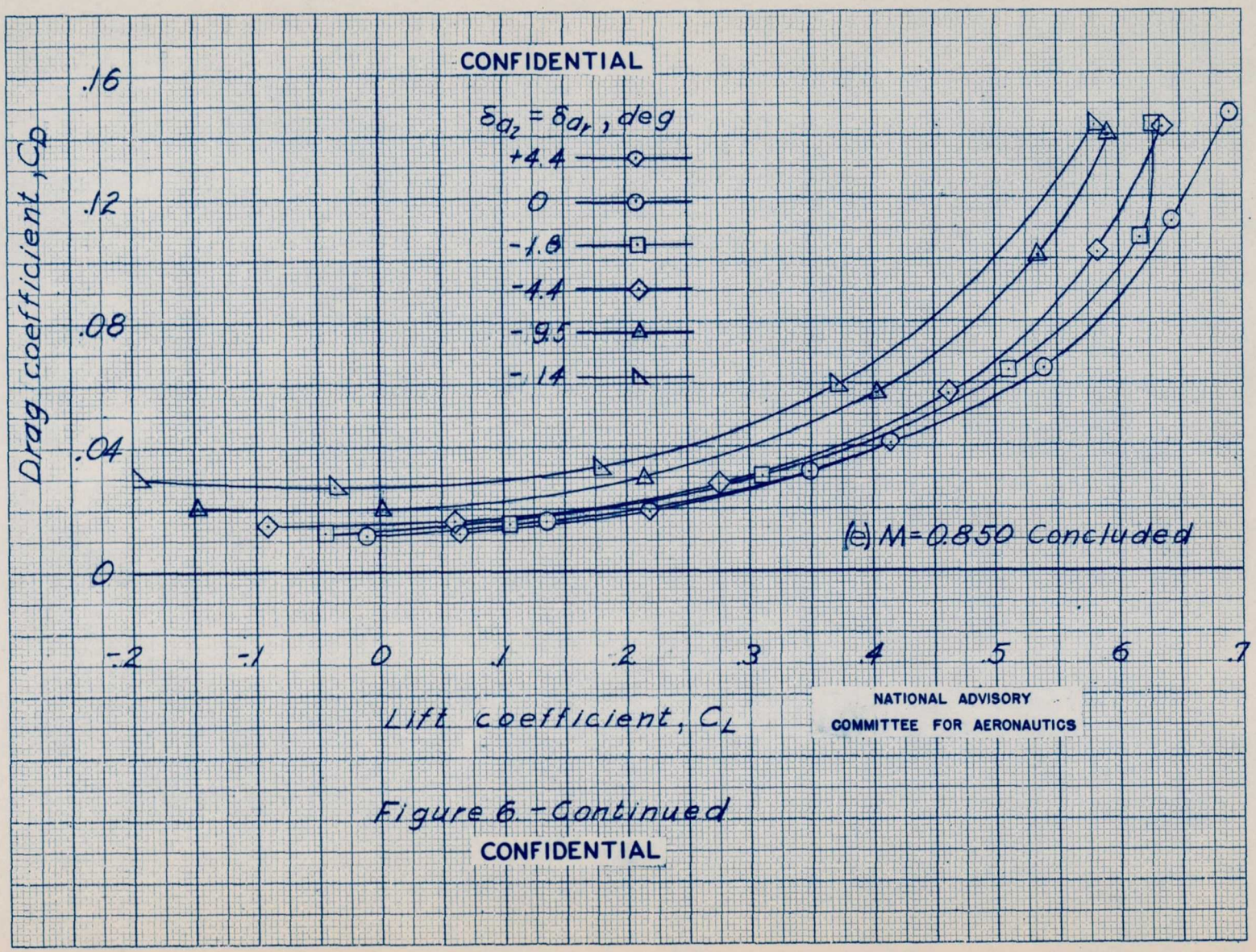

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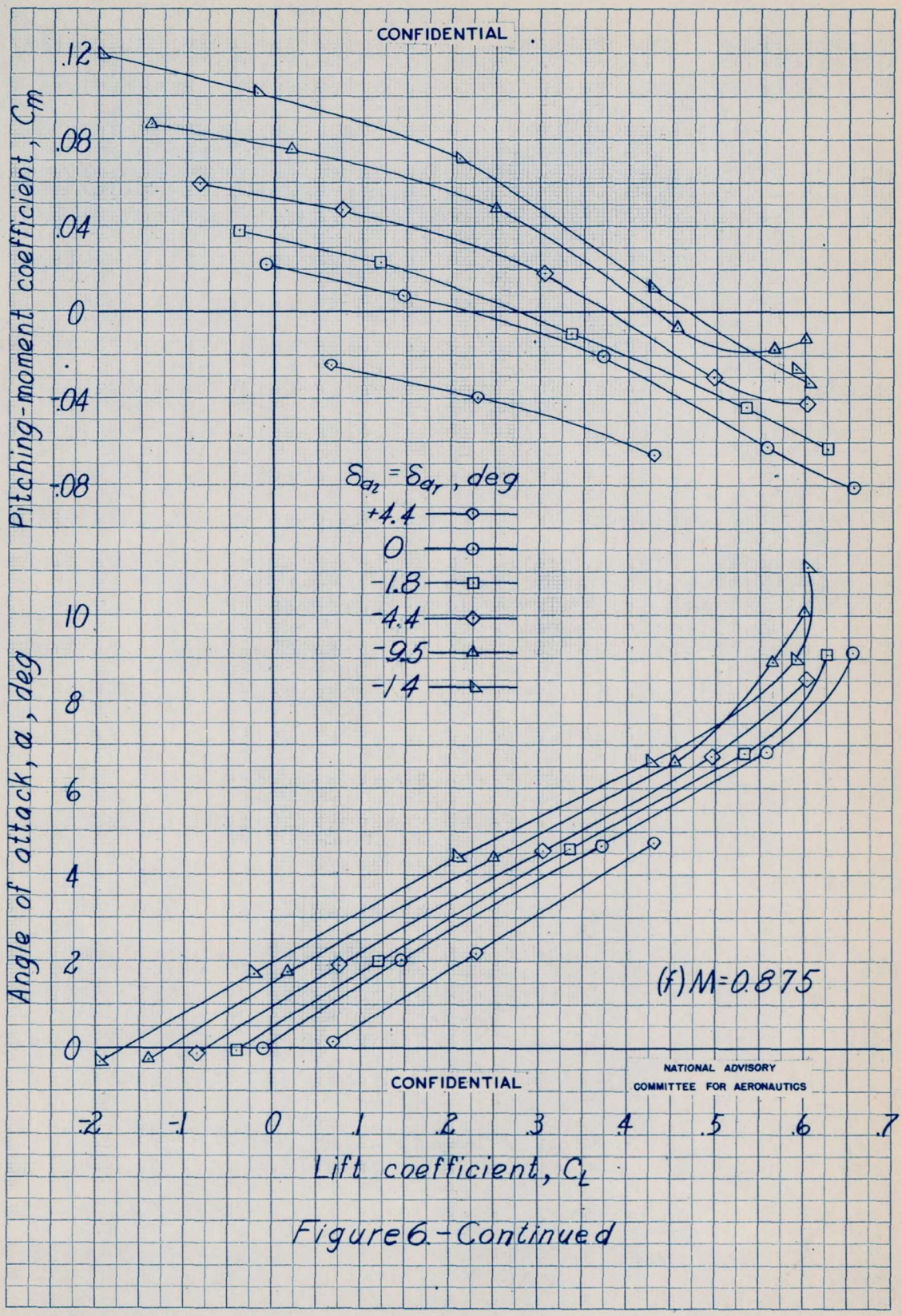

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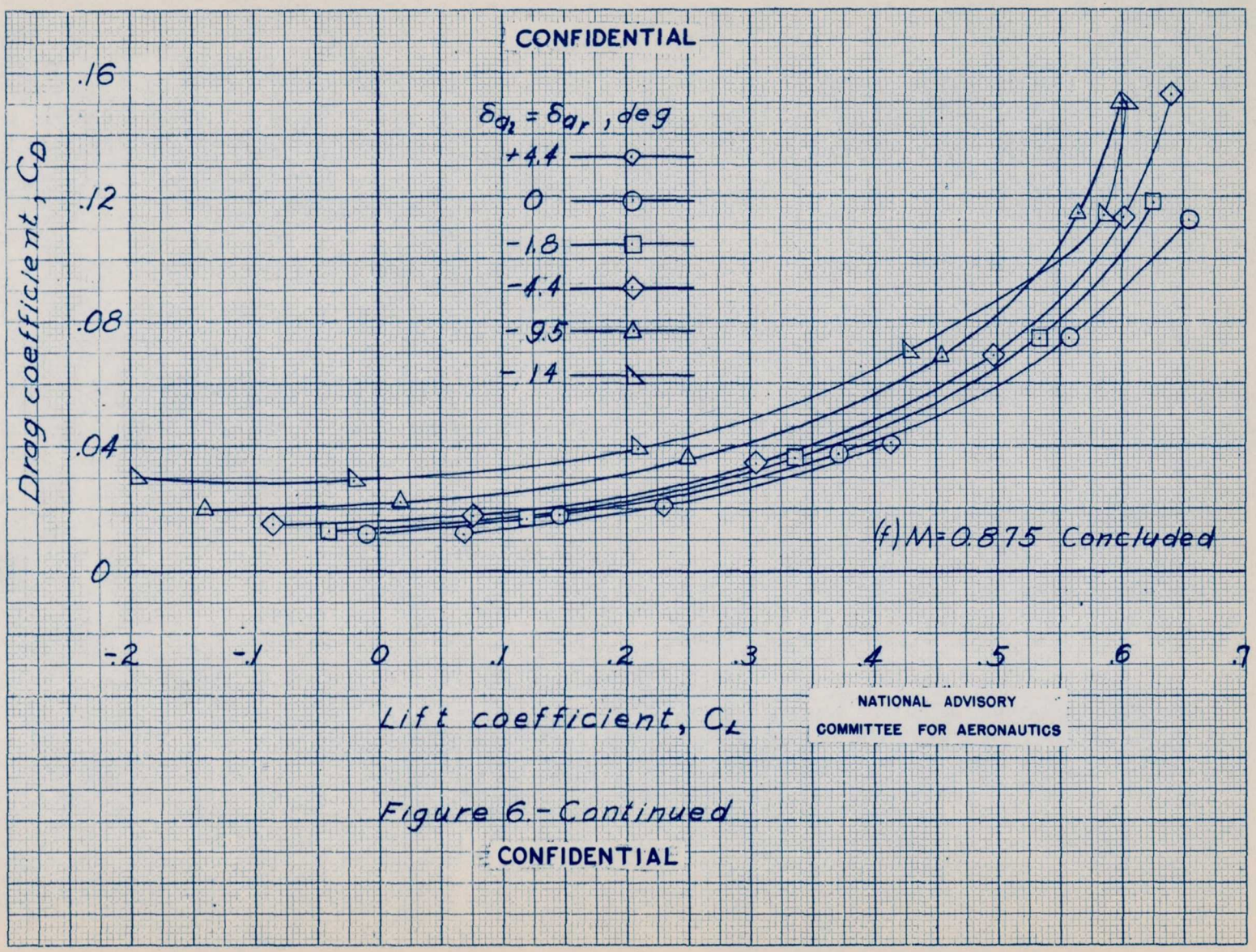

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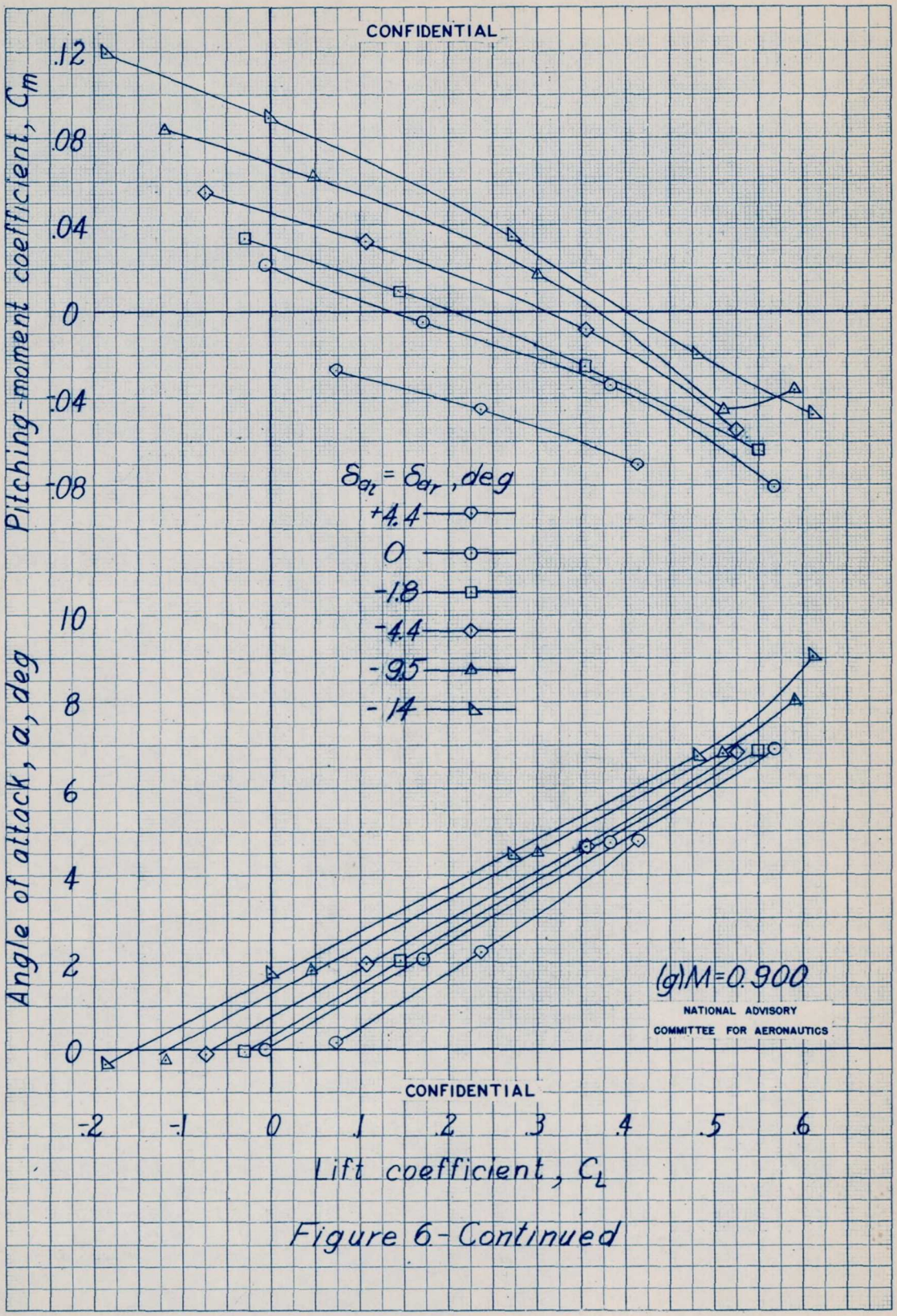

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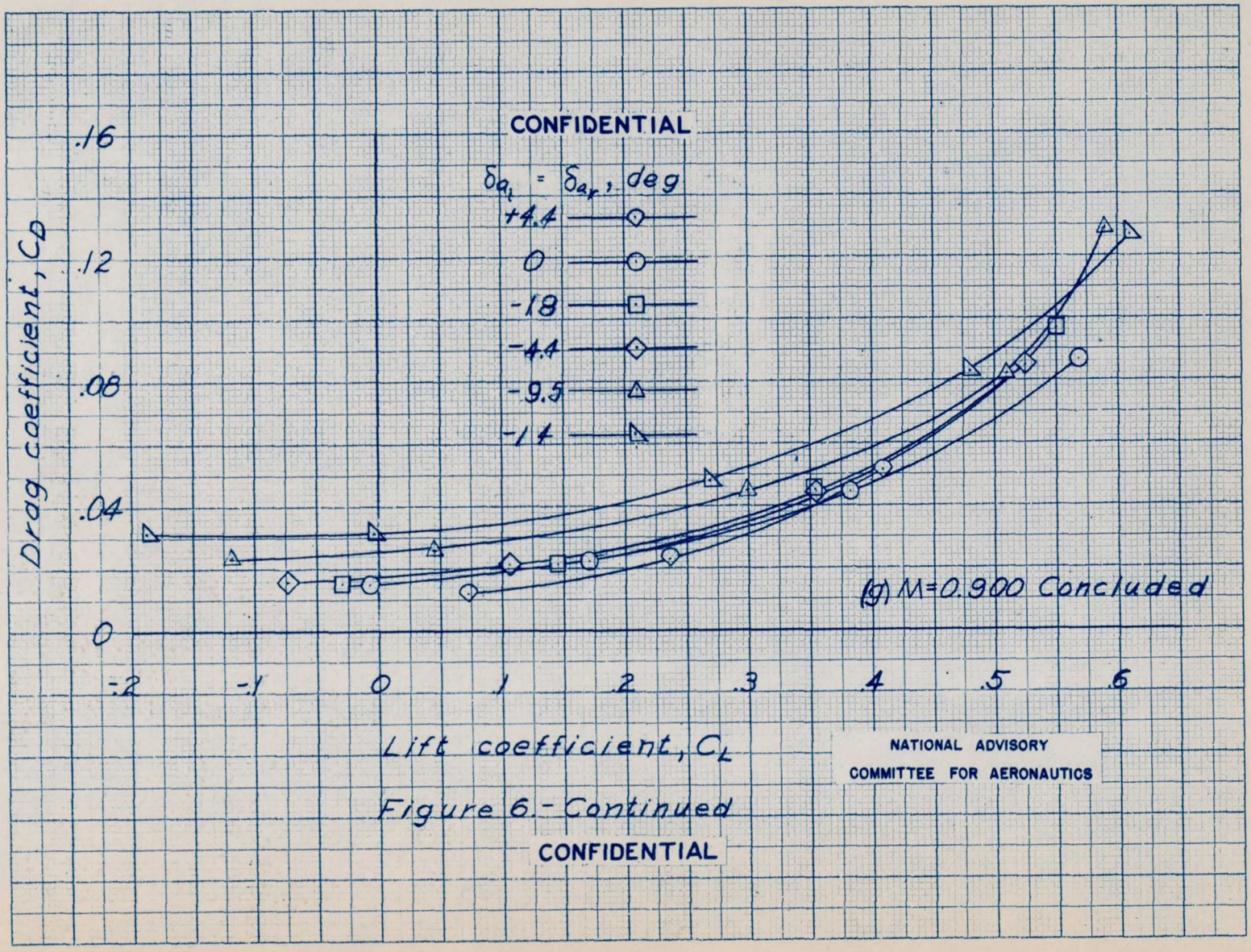

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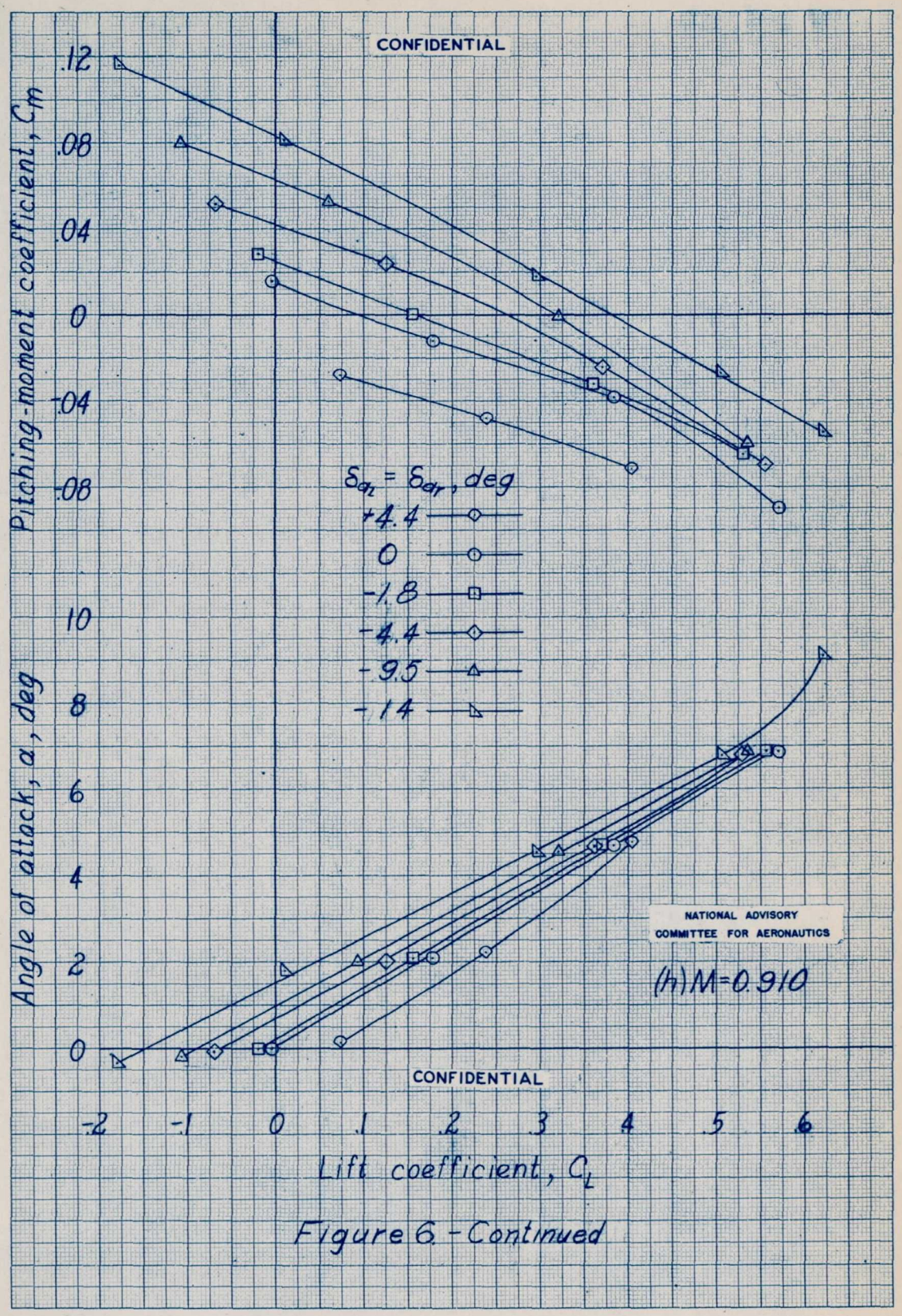

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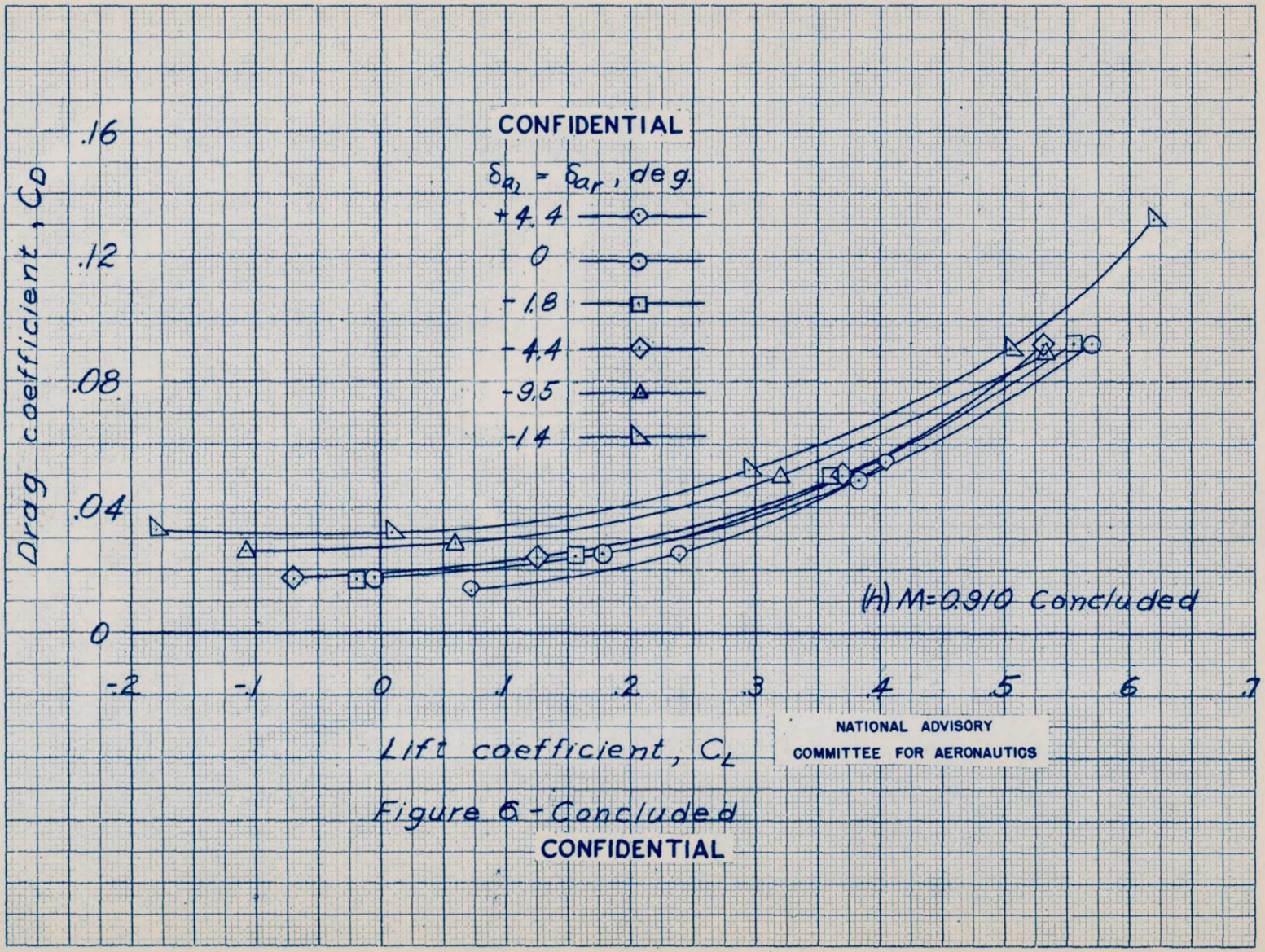

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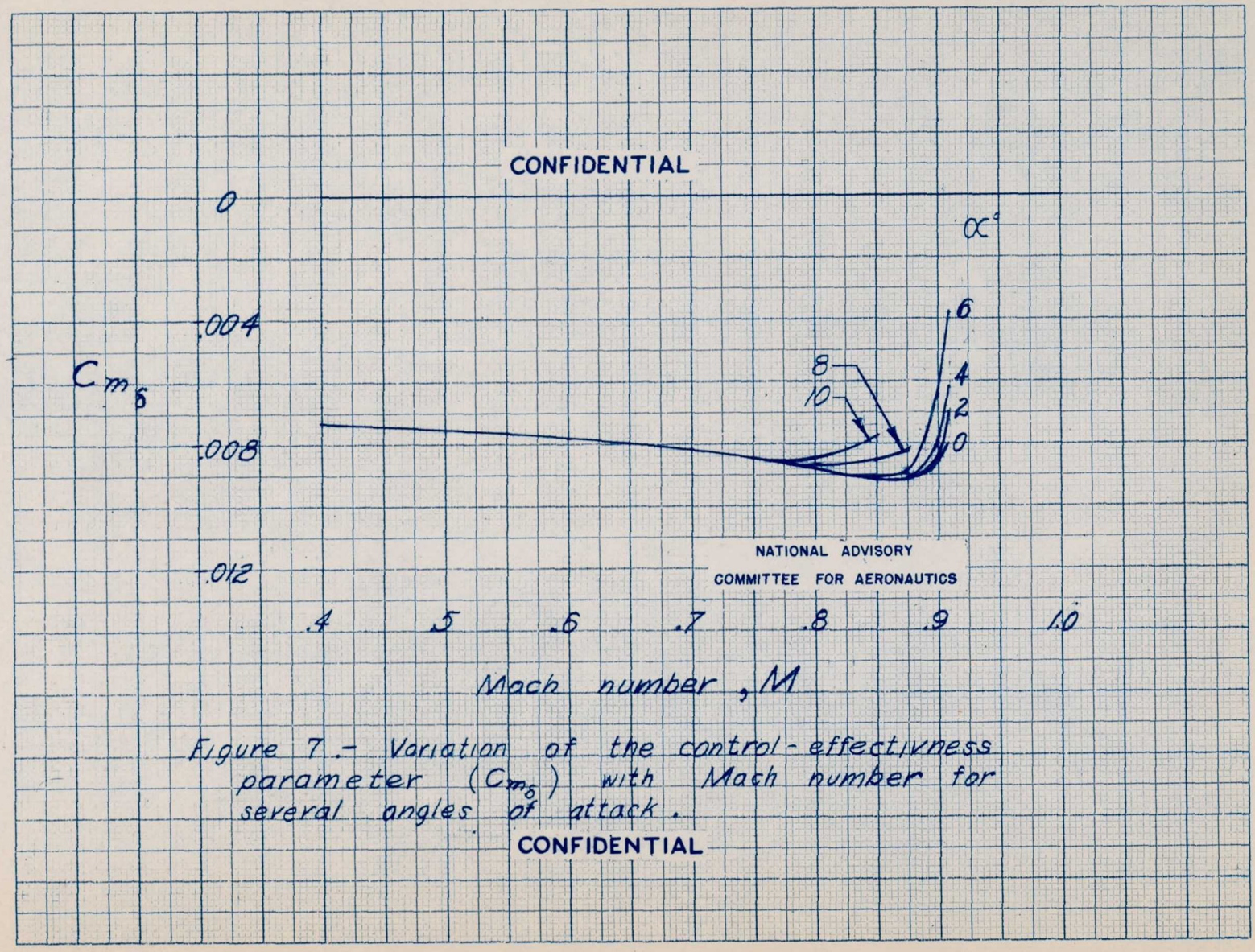

Figure 7.- Variation of the control-effectiveness parameter (C_{m_δ}) with Mach number for several angles of attack.

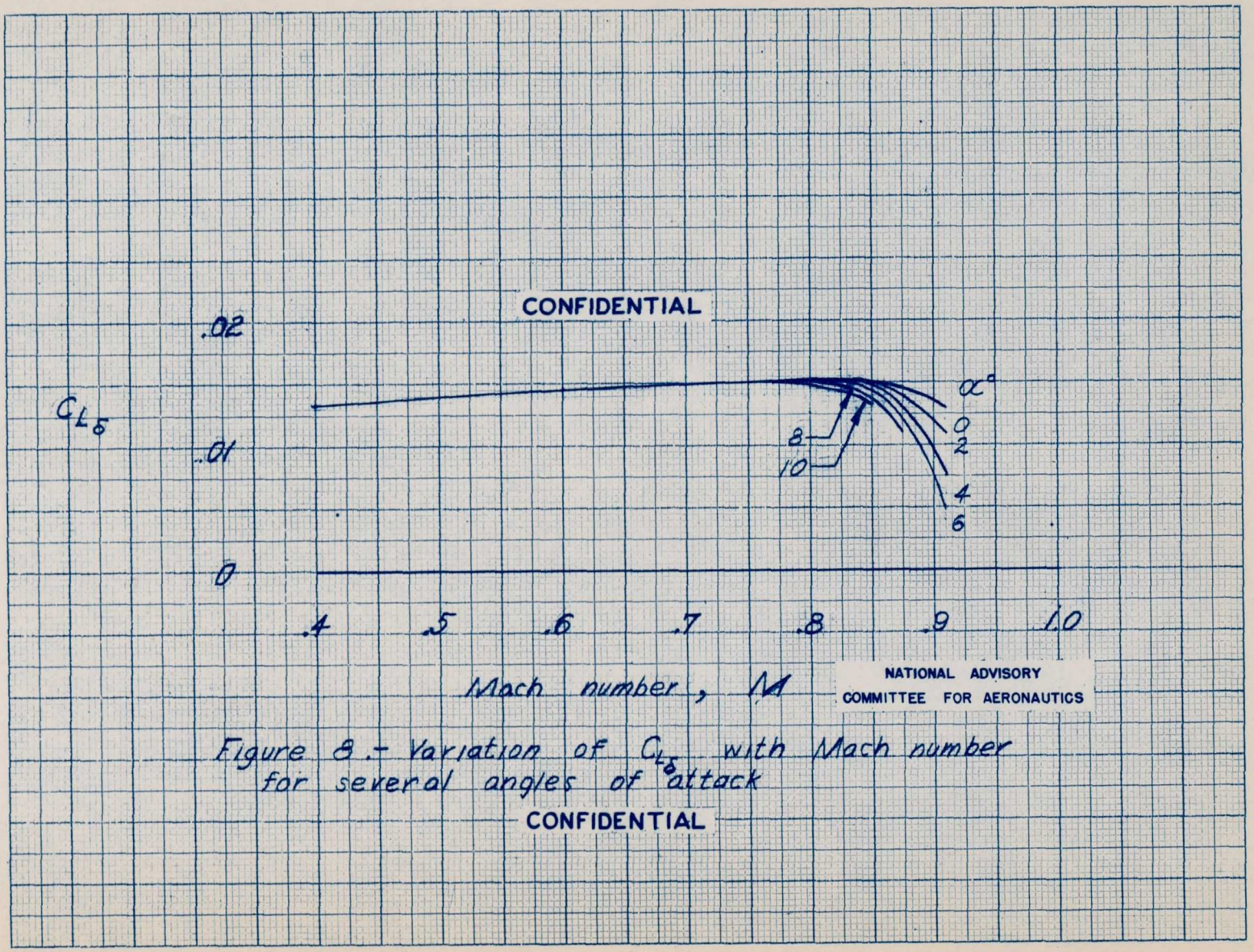

Figure 8.- Variation of C_{L_δ} with Mach number for several angles of attack

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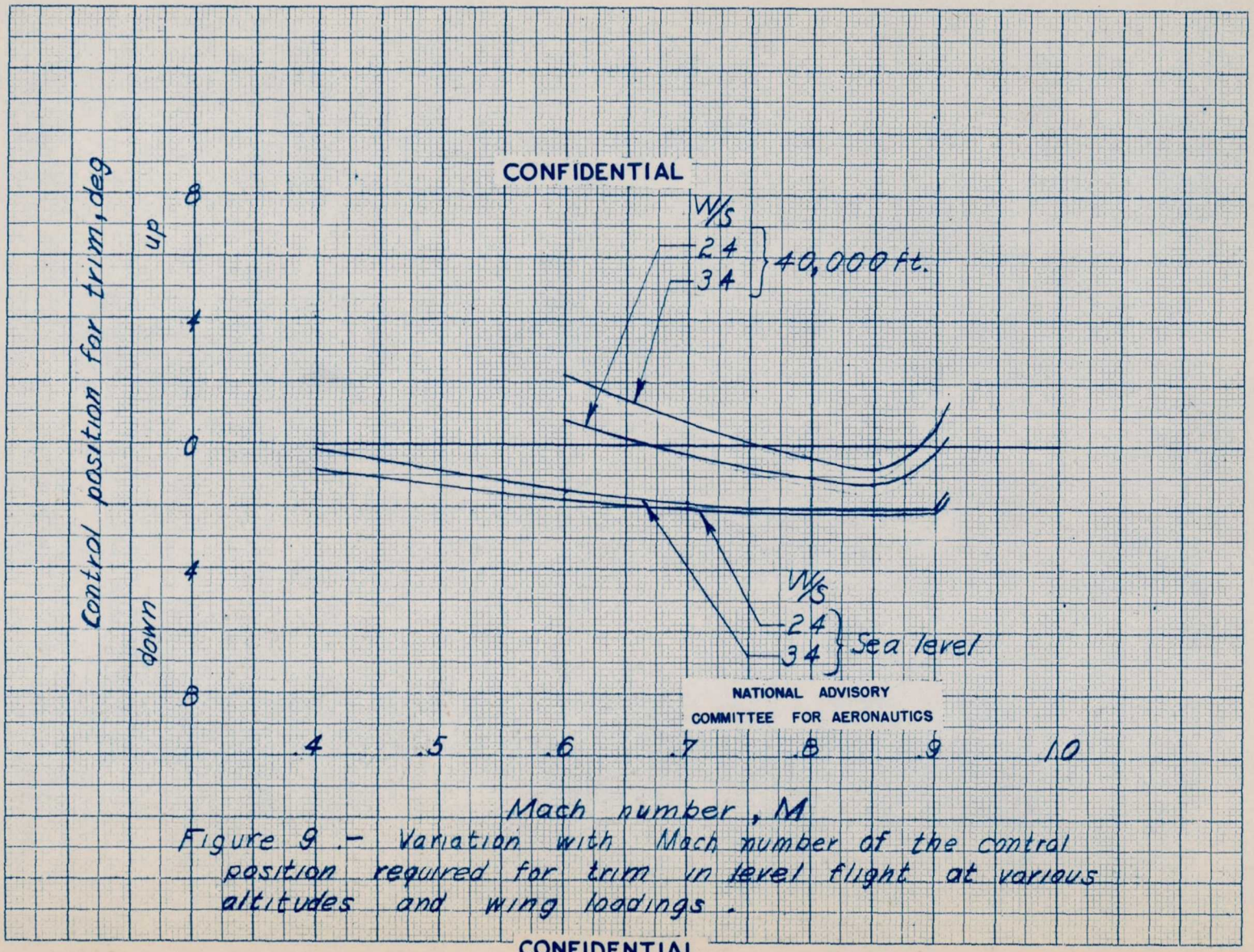

Figure 9.- Variation with Mach number of the control position required for trim in level flight at various altitudes and wing loadings.

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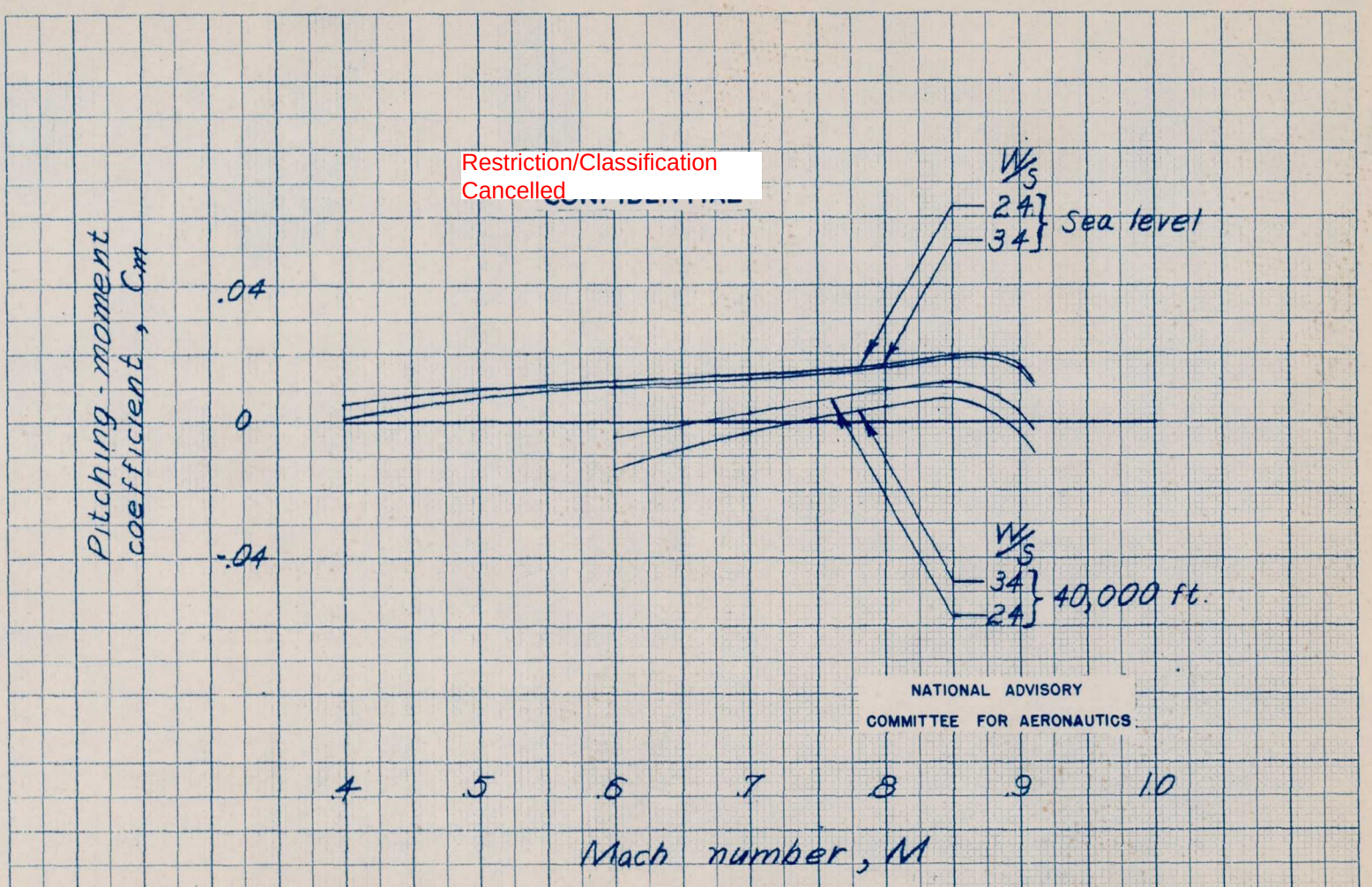

Figure 10.- Variation with Mach number of the out-of-trim pitching moment of the model with zero control deflection for level flight at various altitudes and wing loadings.

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